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...FROM...
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HOUGHTON, MICHIGAN.

THE
ELECTIVE SYSTEM
IN
ENGINEERING COLLEGES.

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BY

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THE ELECTIVE SYSTEM IN ENGINEERING COLLEGES.

BY M. EDWARD WADSWORTH.

Director of the Michigan Mining School, Houghton, Mich.

It was my privilege to present, for your consideration last year, a paper on the elective system as adopted in the Michigan Mining School ; it is now my purpose to continue this subject by presenting some further particulars, and pointing out the conditions under which this system might with great advantage be introduced into other engineering colleges.

To establish a clear understanding between the auditor and the author, it is desirable to divide the matter up into heads which are regarded as cardinal points in the argument.

I. ENGINEERING IS A LEARNED PROFESSION.

This will probably be admitted without discussion ; hence it clearly follows that studies forming an integral part of the course in all engineering colleges, are just as truly professional studies as are those given in schools devoted to Theology, Law and Medicine. Those who follow the last named professions have certainly not excelled the engineer, if they have equalled him, in the task of promoting the happiness, welfare and morality of mankind ; nor can it be proven that success in either of these professions requires deeper study, higher intellect, more experience with men and things, or better balanced judgment, than is needed for the successful presentation of engineering projects. Why,

then, does the public at large hold the engineering profession inferior to the others just mentioned? The answer is because we ourselves have set them the example, and they accept the engineer at our valuation. Educators have, unconsciously perhaps, but none the less truly, proclaimed their own conviction of the inferiority of an engineer's mental needs and equipment by the introduction and continued retention of

II. NON-ESSENTIAL STUDIES IN ENGINEERING COURSES.

This mistake naturally arose from the fact that the early engineering schools or courses were planned in the now clearly erroneous assumption that their training must include a so-called liberal education, or else must prove itself to be the equivalent of the classical courses then in vogue. Further, most of these early engineering courses were grafted into older institutions, under the control of a literary or classical faculty; men whose very training and success in their chosen lines disqualified them to perceive that the study of engineering, if properly conducted, affords just as rigid, logical and powerful a mental training, as can be obtained through the study of any other subjects whatever. Nor has the day yet passed when men can be found who strenuously maintain that such utilitarian studies tend to warp and narrow the intellect; and in their laudable efforts to overcome an imaginary evil, they persist in injecting into engineering courses such subjects as Christian Evidences, British Essayists, History of English Literature, Ethics, Hygiene, Greek, etc. That these subjects are worthy of study and afford valuable educational training is freely conceded;

that they excel engineering subjects as tools for sharpening the intellect, or that they have the slightest bearing upon the professional training of an engineer, or any legitimate place in an engineering course, is emphatically denied. If the engineering faculty deems a knowledge of such subjects essential, it should demand it as an entrance requirement of the engineering college. To include them as a part of a technical course is as illogical and unseemly as to demand that law students pursue a course on pumps, or medical students one on roof-trusses, or theological students one on thermo-dynamics. The engineering faculty, and they alone, are the parties competent to formulate the list of studies for engineering students, and their decision in such matters must be final, if engineering courses are to be freed from driftwood and barnacles.

III. THE NATURAL SEQUENCE OF STUDIES MUST BE OBSERVED.

It is objected by many (1) that under the elective system the student will receive only a disorganized course, and (2) he will finally graduate with a training which is insufficient, because it lacks both depth and comprehensiveness. Neither objection is sound, if the course is in competent hands. The professor of each branch unquestionably knows what subjects a student must have mastered in order to profit from his own instruction; hence, if these are rigidly demanded, his students must necessarily have received a systematic and thorough training in everything having a real bearing on any work they elect to take up. Strict observance of the sequence of studies will, with mathe-

mathematical certainty, force each student to go thoroughly over every subject preparatory to every other subject elected ; hence a disorganized course becomes impossible. It thus appears that, by this system, depth is not sacrificed, but rather increased.

Lack of comprehensiveness is easily and effectively guarded against, by demanding for graduation as many courses as a good student can successfully carry in the time usually available for a college course. Indeed, if the natural sequence of studies be rigidly observed, it is advantageous and perfectly feasible to throw down the artificial barriers that have grown up between the different branches of engineering, and thereby allow the students to enter upon a general engineering training, without any sacrifice of thorough work, or any friction between various departments. Students can select courses in harmony with their dispositions and abilities ; the differentiation will take place naturally. While the degree will not mean that all have taken the same studies, it will mean that every study has been prosecuted with success (which is never the case with a rigid or optional system). Further, it will mean that the student has received a better training for his life work than can be given under any rigid or optional system. Quality, not quantity, is the distinguishing feature of this plan.

There is no reason whatever why the elective system should be confined to engineering colleges alone among professional institutions. If the sequence of studies, which is to the elective system what the keystone is to an arch, is rigidly observed, the system can with advantage be introduced into Law, Medical, Theological or other professional colleges.

IV. THE ELECTIVE SYSTEM CLEARLY SHOWS UP INFERIOR TEACHING, SUPERFLUOUS SUBJECTS AND INCOMPETENT PROFESSORS.

As each professor rigidly demands proficiency in all branches preparatory to his subjects, every student in a class must in a measure serve as an exponent of the ability, thoroughness or honesty of such other professors as have had charge of his previous studies. Any evidence of general inferiority in training in any one subject is quickly detected, and the remedy should be promptly applied.

Everyone who has had any experience under the rigid system knows fully that the range and nature of subjects in such courses are so broad that no pupil is endowed with sufficient talent to excel in all these studies, while the majority of students attain only a medium standing in various subjects. Excellence in some branches is therefore considered to atone for deficiency in others, and the student is passed. Such a procedure is neither necessary nor permissible under the elective system, and if resorted to cannot fail to expose the instructor responsible for it.

Should a professor introduce courses foreign to the work of the school, the fact is quickly made apparent, because no other professor prescribes such courses as preparatory to his own, nor do the students elect them. Hence, this system does away completely with all padded courses, incompetent instruction, or irrelevant matters given merely to fill in a certain amount of time. It makes such instruction serve as a check on the proficiency of the others, produces a coördinate system of studies, and renders possible educational

results which under the old systems would demand a much larger faculty.

V. THE ELECTIVE SYSTEM IS THE ONLY ONE WHICH
CAN MAKE FULL PROVISION FOR THE DIFFER-
ENCES IN TEMPERAMENT, TASTE AND TAL-
ENTS, WHICH MUST ALWAYS EXIST BE-
TWEEN THE VARIOUS MEMBERS
OF THE STUDENT BODY.

The province of an educational course is to develop and sharpen the intellect; it cannot create brains, nor can it by any method whatever eliminate those differences in men which are implanted in them by the Author of Nature. It is difficult to understand why the attempt should be made to perpetuate an educational bed of Procrustes; for the writer maintains that this very thing is attempted when, contrary to the teachings of Nature, it is insisted that students be divided up into arbitrary classes, every member of which must be forced to go through exactly the same scheme of studies without reference to his natural tastes and abilities. The results of this procedure are too well known to need further comment here.

Under the elective system the student selects that work for which he has been properly endowed by nature; he takes far greater interest in it, and the results are deep and permanent. So marked is this that no instructor in the Michigan Mining School now hesitates to demand of his men far higher and better work than even the most sanguine could ever hope to get under the old rigid system. Even if the elective system does demand higher work in each branch, and

a more proficient preparation for each study, the student himself readily sees the object and justice of each requirement, and cheerfully accepts an obligation which carries with it freedom in choice of studies and avoidance of those non-essential. All this acts like oil upon the machinery, and enables the product to be turned out with little noise, friction and wear and tear.

It is frequently urged that a student is not competent to draw up a proper list of electives. If this statement be true, does it not carry with it the inevitable conclusion that he is even less able to select his studies for four years, before he has had even a day's experience in the course? Is not this exactly what he is required to do, when he is held to a rigid or optional system?

But experience shows that this statement has no basis in fact. The natural sequence of studies guides the pupil when making his selection, and, assisted by advice from his teachers, which is always freely given, he rarely goes astray, unless his abilities and tastes are misjudged. This rarely happens and the mistake is easily remedied. No such means of rectifying even slight mistakes exists under a rigid or optional system. It is necessary to take the "system" and take all of it, or to take nothing. It may not be amiss to call attention to an exactly parallel case in actual engineering practice. Those engaged in electrical work know that a comparatively short time ago every electrical plant, from dynamo to lamps, was a representation of some "system," and it is likewise known that not one of those systems was free from many defects in details.

To-day all this is changed. An electrical plant may represent the product of a dozen or more different makers or "systems," because each part has been selected solely on its merits for the particular purpose in view. It represents one case of the beneficent workings of the elective system in the practical affairs of life.

Under the rigid system, a student who finds that he has misjudged his abilities must either struggle through in some way, thereby building for his future a structure which is rickety and valueless, or he must quit the course altogether, receiving, as a reward for his work up to date, only a practically worthless foundation for a mental structure which will never be completed. In the case of a similar mistake under the elective system, the student may indeed have to change some of the lines of the edifice, but little of the material is wasted, since it can nearly all be used again in a new structures designed with a better knowledge of his capacity and needs.

Since engineering is largely a matter of economics, is it not wise to have the student make the first application of this principle when expending his own energy and time?

VI. CERTAIN CONDITIONS ARE ESSENTIAL IF THE ELECTIVE SYSTEM IS TO BE A SUCCESS.

It must be clearly recognized that every educational institution has its individual peculiarities; hence before undertaking the introduction of a new system, or a modification of an old one, every school must make an exhaustive inquiry to determine the relations be-

tween the proposed course and its environment, constituency, faculty, trustees, equipment, object, etc. That scheme which is most in harmony with these should be adopted, and in determining which one most nearly meets the required conditions, nothing is more necessary than a liberal use of that very rare commodity, common sense.

It is surely unnecessary, when addressing a body of engineering educators, to point out the uselessness of mere copyists or servile imitators; temporary success may crown their efforts in some cases, but not in one like this, because in every problem the requirements are so diverse. In every case the scheme must be worked out anew, in every detail, from the very foundation.

If the writer were asked whether he would introduce into any other school in America the elective system as now adopted in the Michigan Mining School, he could conscientiously give but one answer—most emphatically, “No.” The reason for this is that, while the system seems perfectly in harmony with all its needs, this school is unique in its nature, and its counterpart is not to be found elsewhere in this or any other country. While its system and methods are the proper ones for this school because they were specially designed to answer its wants, they will no more meet perfectly the diverse necessities of other schools, than will one prescription cure every disease.

Notwithstanding this, it is firmly believed that the logic of the system is perfectly sound, and contains more largely than any other the elements of success for any school, if its details are carefully and consci-

entiously worked out so as to meet the peculiar needs of each institution. It seems impossible for any educator to study exhaustively the history of education and the spirit and needs of our own time, and then fail to draw the conclusion as stated to the Society last year, that the elective system is the coming system, and that sooner or later it will find its way into every institution of higher learning in the land.

Every educational scheme, and the elective system more than any other, demands for success that schools be conducted on sound business principles, the most important of which are here mainly condensed from the writer's first "Report to the Board of Control of the Michigan Mining School."* The governing board must be composed of experienced, able, judicious and conscientious men; they need not of necessity be educators or engineers, but they should have the wisdom to perceive that the successful direction of a higher educational institution requires experience and ability on a par with that demanded in any other business or profession. They must realize that no success can crown their efforts unless they clearly understand that their duty consists entirely in formulating the objects of the institution, providing the means to reach those objects, choosing an able and discreet Director or President, and seeing that he attends to his duties. Assumption of any other power is mathematically certain to cause friction and throw painful obstacles in the way of progress.

It is clearly evident that a board will be more excellent in proportion as its members are graduates of

* Pp. 70-80.

higher institutions of learning, and if possible, one similar to that over which they are presiding.

The success of the institution depends largely upon the chief executive officer and the faithfulness with which he is supported by the board and faculty. The president need not of necessity be an engineer, but it is absolutely indispensable that he be an able and experienced educator, a man of broad gauge, liberal spirit, unbounded energy, perseverance and firmness. To him should be left, without any interference whatever, the carrying out of the plans formulated by the board, and he should be held strictly accountable for results. Nothing short of incompetence should be deemed a sufficient reason for interfering with his plans.

The president must make a study of the institution as a whole; formulate the results to be reached by each official of the school in order to carry out the general scheme; see that these results are obtained; be empowered to discharge, without recourse to others, any official found to be incompetent. He must allow each of his associate officers full liberty to reach in his own way the results demanded of him, rigidly abstain from interfering with his work, and aid him whenever possible. With a suitable president, competent faculty and close adherence to these methods, it is possible to introduce an elective system which will meet the needs of the student and every live professor, and show up incompetents. It will force the removal of that kind of driftwood which lumbers up so many of our educational institutions, simply because the president is not granted the proper authority to handle such material and lacks the backbone to demand its removal.

by the board. Unless someone oversees the instructors and is empowered to remove incompetents, success will not be likely to crown any scheme, and least of all the elective system.

VII. THE ADVANTAGES OF THE ELECTIVE SYSTEM.

They may be briefly enumerated as follows :

(a) It lightens the labor of the instructors, *i. e.*, removes much of the drudgery, makes the work far more a labor of love, and enables each one to give as extended a course in his department as he wishes, without interfering with another professor.

(b) It greatly reduces the friction between faculty and students, almost does away with faculty meetings, and renders the necessary regulations few in number.

(c) It renders examinations almost unnecessary, grades the student by his daily work, removes the padding of courses, shows up inefficient teachers, and allows the professors and the institution to get rid of incompetent pupils with almost no friction.

(d) It results in better and higher work in each subject, and develops the best that is in each student.

(e) It is more economical, both in money and time, than either the required or optional systems, *i. e.*, a smaller faculty accomplishes the same results.

(f) It enables an institution to keep pace with the rapid development of the various branches of engineering, without the introduction of new faculties and new degrees with their attendant evils.

(g) It serves as a safety valve for the students' pent up energies, and almost does away with class rebellions, especially those due to some particularly obnoxious

ious professor, or to the suspension of some popular student.

(*h*) It does away with the practice of hazing and most of the other disgraceful customs of students in educational institutions; it renders the student more manly, and in a professional school allows a man to attend to athletics and his studies, without that demoralizing sacrifice of truth so fearfully prevalent.

(*i*) It proclaims to the public, and with perfect truthfulness, that not only has the student "gone through" certain studies to obtain a degree, but that each of those studies has "gone through" him; in other words, that no student has been allowed to slide through some studies in which he was weak, because there were others in which he was proficient; nor has he been graduated simply because of his excellence in athletics.

(*j*) It unites into one harmonious whole the studies that are usually classed as undergraduate with those that are called graduate, and leads the student to consider them all as desiderata for his work. It broadens his field of view, inclines him to pursue further study, and diminishes his tendency to contract the megacephalous disease.

VIII. EXPERIENCE IN THE USE OF THE ELECTIVE SYSTEM AT THE MICHIGAN MINING SCHOOL.

When the writer assumed the position of Director of the Michigan Mining School, nine years ago, the institution was in its infancy, and no systematic course of instruction had been laid out. The rigid system usual in engineering schools was the only one then

available, and it was accordingly introduced. The rapid development of the school soon pushed this system to its ultimate results, namely, the wishes of each member of the faculty as to the work he thought should be given in his department were gratified. There resulted, in consequence, an engineering course which could be successfully coped with, only by one exceptionally able both mentally and bodily. Seven to nine hours daily were needed in the class-room and laboratory, and all preparation for this work had to be done in outside hours.

Every instructor realized that the system was crushing under its own weight, and that prompt relief was imperatively necessary. When casting about for a solution of the long foreseen difficulty, the Director, among other things, interviewed each member of the faculty, separately, as to his views on the desirability and practicability of an elective system. He properly considered that such views would be more than usually valuable, since the faculty then contained men who were not only experienced in the methods and systems used in schools in Germany and in the Universities of Harvard, Pennsylvania, Wisconsin, Ohio and Georgetown; Colby and Bowdoin Colleges; and the Michigan Agricultural College; but they were also familiar with the methods employed in Columbia, the University of Michigan, the Massachusetts Institute of Technology, and in most of the other leading schools of the country. The consensus of opinion was that such a system, while advantageous in a literary institution, presented insurmountable obstacles to its introduction in a technical institution like the Michi-

gan Mining School. The Director, however, saw no other solution for the difficulties then encompassing the course of study, and, notwithstanding the discouraging outlook, determined to test the practicability of laying out a suitable scheme; from time to time he consulted each instructor as to his wishes in all matters relating to his department. After several months' labor the details of the plan were finally worked out, obstacles surmounted, conflicting interests harmonized, and the completed work submitted to the faculty and the board. It was promptly and unanimously adopted by both bodies, and has proven to be the greatest single advance the Michigan Mining School has ever made.

The faculty meetings have been reduced from one or more weekly to five in forty-five weeks, and, unless some emergency arises, one or two meetings a year will in the future be all that will be necessary to transact the business that is required of the faculty as a body.

The system has also brought about a simplification of the other work and enables it to be rapidly done, because the Director is charged with the duties that usually devolve upon a faculty, and because each professor has absolute control over his department and the students in his classes. The professors in charge of departments are responsible to the Director, while each of the other instructors is directly responsible to the head of the department with which he is connected.

The regulations of the school have been greatly reduced in number, and so arranged that the student himself is specially interested in seeing that they are observed, since if they are not, his own act takes him

out of the institution and closes the door behind him, in most cases without the intervention of the faculty or Director. Everyone who has debated long hours over the case of some student, whether it was "to be or not to be," can realize what a relief such automatic action is for a long suffering faculty. These changes have all grown naturally out of the elective system, with the result that the Michigan Mining School has had one of the pleasantest, most profitable and harmonious years it has ever experienced, although it has never developed enough disturbance in its history for the newspapers to take up its discussion. Not a single professor or student desires to, or would go back to the old system and while further experience will undoubtedly indicate various modifications of details, it can certainly be considered at this time that the elective system is an unqualified success.

DISCUSSION.

PROFESSOR DEVOLSON WOOD wrote that he thought elective studies in engineering courses are, as a rule, demoralizing, that they lower the standard of mental discipline, are costly to the institution, and are unnecessary. This is no reflection upon an institution which can equip and maintain different courses, which courses, it is presumed, are elective. As there are exceptions to all rules, so in this case the Michigan Mining School may have found advantages even if it has not yet discovered disadvantages.

A graduate, after years of professional practice, said, "A student should understand at the outset that he is to pursue any study that is required of him ; for he

may find that the first thing he will have to use when he leaves college is that which he most despised when in it." Lay greater emphasis on the "how" and on the "what" is studied. One straight, solid, thorough course without electives will make stronger men than one weakened by electives.

PROFESSOR J. GALBRAITH said that he had listened with great interest to the paper. The difficulties mentioned in connection with the ordinary system are more or less acknowledged by all. The great amount of work required of a student under this system, and the undue proportion which the dry and apparently useless work bears to that which is interesting, make the curriculum to some extent repulsive. The desire of individual professors to aggrandize their own departments and to arrange the curriculum to suit their special requirements may in some cases produce a bad effect. The speaker had hoped that the paper would make clear a method of avoiding some of these difficulties, but was obliged to confess that he did not see the solution in what had been said. It appeared to him that the only persons who are qualified to lay down a curriculum in the professional courses of a technical college are the members of the faculty, and they require to bring their combined experience and knowledge to bear upon the problem. The student certainly is not in a fit position to select the various subjects leading to a professional degree, and decide the order in which they are to be taken. Of course, if an institution decides to give its degree in one subject of study as distinguished from a professional department, it would be quite a proper course for the student to

consult with the professor of that subject as to the preliminary studies that might be necessary, and to follow his advice.

Even this is very far from being an elective system. The professor makes practically a fixed course; just as in the case of graduation in a professional department the faculty lay down a fixed course, and where the choice of the student comes in after selecting his subject of graduation is not very clear. No practical method can be devised of making the individual studies in a professional course elective if the degree is to be worth anything, and the speaker did not think that the term "elective system" ought to be used where this is not done.

PROFESSOR WADSWORTH stated that there had not been the slightest lowering in the work, but instead of that a very decided raising. The professors of to-day demand of their students in the Michigan Mining School, that which not one of them would have dared to demand the year before, simply because the burden then was too great; the men could not stand the strain of so many subjects as those demanded by the required courses. In his own classes he had done work that he was ashamed to do, simply because he must do it or the men could not by any possibility get along. The burden was beyond that of human endurance. The student now takes fewer subjects in the same time, but does higher and better work.

If modern languages, together with everything else that has been asked for from time to time, are made a part of the engineering courses, what opportunity is there for sufficient, or even for any, real engineering

training? If engineering studies are necessary for a man, it will not do for him, in his engineering course, to spend most of his time on modern languages and on a variety of unprofessional studies that might be interpolated in an elective course. These studies should be preparatory.

The elective system does require of a man that he shall take a definite amount of work in order to graduate; he must take the same amount that is required of him to graduate in a prescribed course, and it must be strictly in the line of professional studies. The idea that, in an elective system, a man can graduate if he has spread himself over any given number of studies without regard to their relations, is a thing that exists in no elective system outside of a kindergarten. It cannot exist. No man can study calculus until he has studied algebra. The sequence of studies must be followed, and the moment this is done, the student finds himself forced, practically, into a proper course of study. The elective system is a natural and logical system and it reaches the ends that every one has been hoping to obtain in the required courses. It removes from each student's selected course the special studies in which he cannot naturally succeed.

PROFESSOR GALBRAITH suggested that in that case the course agrees with ordinary practice, but contains only what are considered necessary subjects.

PROFESSOR WADSWORTH agreed to this, saying that for each student his selected course became for him a fixed course—fixed by his natural tastes and abilities, and not fixed by a faculty who knew and could know nothing about him.

He continued by explaining further the operation of the system described. When the professor of hydraulics demands of a student a certain amount of study, he does not say that the student should have everything in the curriculum, but he says that the student who comes to him shall take calculus, shall take analytical mechanics, shall take physics, shall take chemistry, or whatever studies he wishes. The student, when he enters upon his course, knows that if he is to take hydraulics, he must prepare himself accordingly. If he wants metallurgy, the professor has laid down the ground previously which he must cover to take metallurgy. He cannot graduate under one professor and follow only one professor's course, for no three professors even can teach enough subjects to give a man his degree. The student can, if he wishes to do so, on one hand devote his time more particularly to metallurgy, chemistry, and geology as applied to mining; or, on the other hand, to the civil engineering or mining engineering sides. Or again, he can give most of his time to mechanical engineering or electrical engineering as applied to mining, and give less to the metallurgical and chemical sides. In this way he can follow his bent of mind and tastes; for as the individuality of the student varies, so he can modify his course; but he cannot graduate with an inferior training. The training is deeper and more thorough than it is in the required courses. The student may not take as many studies, but he does better and more thorough work.

There seems to be an inclination to make the criticism that it is impossible for a student to choose his

course wisely for simply one year, and yet he is ordinarily required to choose his life work for four years ; that excites no comment ; that is considered perfectly proper. If a man can enter a school before he has ever had a year's experience in any professional training, and select his course for four years, is he incompetent to choose it for only one year ? That does not seem logical. With a knowledge of the sequence of studies, and under the guidance of professors, the speaker believed him capable of choosing and choosing well.

There is a difficulty, and a very serious difficulty, in the elective systems in many of the literary colleges ; and that difficulty will arise in the engineering colleges unless there is a controlling supervision. That difficulty is the introduction of "soft" courses. The faculty must be under such authority that the moment any member undertakes to bid for students by giving "soft" courses, there will be a certainty of his going out of the institution. This is absolutely essential. No good system of any kind, required or elective, is possible unless incompetent professors are quickly dispensed with. The president, or whoever is in charge of an institution, must have backbone and authority enough to say that such men must go. This is particularly true with the elective, and ought to be made true of every system.

PROFESSOR H. S. JACOBY desired to ask a question as to whether there had been in the writer's experience an indication of a disposition on the part of any student to choose too one-sided a series of subjects.

PROFESSOR WADSWORTH replied that there had been none so far, perhaps because the system is guarded so that a student can not very well do this.

PROFESSOR JACOBY said he had a great deal of confidence in the ability of young America to choose very many more things for himself than he is often given credit for, and therefore had not much fear in that direction, and he felt very anxious to ask the question to more authoritatively learn the writer's ideas upon it.

PROFESSOR STORM BULL expressed, as his understanding of Professor Wadsworth's practice, that he allows the student to say whether he wants to study English or anything of that kind.

PROFESSOR WADSWORTH explained that, in the elective system described, the studies are limited to professional studies. English and similar studies are preparatory. These are not in the engineering curriculum. With free opportunity for the student to choose from modern languages and many other non-professional studies, in connection with his engineering work, nothing can be done with an elective system and obtain a high grade engineering course. The student will not be properly an engineering student. He will become a classical or a literary student, as that is the line of least resistance.

The system of electives commences in the Michigan Mining School at the beginning, *i. e.*, with the freshman, immediately upon his entrance.

PROFESSOR BULL asked what was required for admission, whether either English or foreign languages?

PROFESSOR WADSWORTH answered that the requirements for entrance with the former rigid courses had been somewhat peculiar. What had been then required, and what is required now under the elective system, are somewhat different things. The State

schools of higher education have a certain relation to the high schools; and there is now required a regularly established and satisfactory course of study in the high schools, if their diplomas are to be accepted for entrance. A special four years' course of study has been laid out by the Michigan Mining School, and recommended for the high schools to follow if they wish their diplomas to be accepted. This course includes English literature, the French and German languages, physics, political economy, rhetoric, logic, zoölogy, botany, astronomy, trigonometry and various other studies, such as in the old days constituted much of the old fashioned college course outside of Latin and Greek. French and German are carried through the four years. Formerly, under a special certificate for admission to the Mining School, only the mathematics, physics and astronomy were demanded as preparatory to the professional studies, something the same as is similarly the case in a law or a medical school; that is, there was required algebra through quadratic equations; arithmetic with the metric system; geometry, plane, solid and spherical; physics; elements of astronomy, and book-keeping. Book-keeping was required simply because in mining work the students ought to understand mine accounts.

At this time, if a student will satisfactorily pass an examination at the Mining School in the subjects named above, he will be admitted. The situation is peculiar; everywhere in the land, and particularly in a mining district, there are a great many young men who have gone into practical business when they were about fifteen or sixteen; later, when they have arrived at the age of eighteen or twenty, or

twenty-five, they have a desire to obtain an education. The high school tells them, "You must come to us four years, then you must go to some other institution three or four years to obtain your degree." This is a virtual embargo on these young men. They often have great ability; they work hard and they make the best students. Therefore these men are informed that if they will come to the Michigan Mining School, after a two years' special course in the high school, and also after they are nineteen years of age, or else will come to the institution and pass its examination in the special subjects above named, they will be allowed to enter. No difficulties have thus far resulted to the Mining School from doing this. Experience has shown that graduates of the high school do just as well in the higher and harder work, and stand the wear and tear of an engineering professional training in the Mining School, as well as do the graduates of colleges and universities; oftentimes better, for the simple reason that the majority of the latter have been trained to memorize, and do not know how to reason. They have committed to memory Greek and Latin grammars and works of that kind, so that they have unfitted themselves to think over practical questions. The instruction given students at the Michigan Mining School incorporates a vast amount of practical work as an application of the principles taught.

PROFESSOR W. F. M. Goss said that if he understood the paper, it stated that the elective system would do three things: It would avoid the overcrowding of courses; it would operate to cut out subjects which have no real value, if any such exist; and it would serve as means by which undesirable students

may readily be sent away. Since these are all matters which under any system of courses are well within the control of the faculty, the real claim seems to be that the elective system will somehow protect the faculty against itself. He thought that the average faculty needed no such protection.

PROFESSOR WADSWORTH replied that the three things mentioned covered a part of the advantages, since experience shows that the average faculty fails to accomplish these objects with a required course.

PROFESSOR G. W. BISSELL seemed to think it not a fair statement that a student who enters a college and chooses one of the engineering courses, and who afterwards changes his course, loses four years' time. He had known instances in which a student entering in civil engineering had changed to electrical engineering after one year, without sacrificing very much of the first year's time or losing very much of the second year's time; the student need not throw away the whole four years if he enters in the ordinary way and then finds that he has made a mistake and changes to some other course. Then as to the elective system, or the elective feature of the system discussed by Professor Wadsworth, if the student were to enter any engineering college and elect, for instance, hydraulic engineering, he would follow out much the same course of study under the elective system at the Michigan School of Mines as he would under a prescribed system in any other engineering college of high standing, provided, of course, that the professors in both schools have the same ideas—and there would not probably be much difference—as to what constitutes a proper course of study in hydraulic engineering. It seemed

to be not very different from specializing, or taking a special engineering course in other institutions of the same grade.

PROFESSOR ALBERT KINGSBURY said that he could hardly see how this elective system could apply in the average college. Indeed, his understanding was that Professor Wadsworth does not think it will so apply.

PROFESSOR WADSWORTH replied that his position was that, while the elective system can be used in every college, the special course that had been arranged for the Mining School would not, as it then stood, apply to the average college; he would always vary it with the special conditions of every institution.

PROFESSOR KINGSBURY thought that he could hardly make a beginning with an elective system in a college such as the one in which he is occupied. The elective system which has been discussed appears to be one in which the student is lead to suppose that he is doing the electing, while in fact the faculty is doing it, and the chief gain comes from a mere matter of policy in working upon the human nature of the students.

PROFESSOR WADSWORTH replied by asking if it is not always well to oil the machinery, in order to make it run more smoothly and with less friction.

PROFESSOR KINGSBURY further explained as his understanding of the system that, if the student is to take applied mechanics, the professor says to him, "You must have the subject of calculus," and when he attempts to study the calculus he is told, "You must first know algebra," and when he wishes to study algebra the professor says to him, "It is necessary for you to know something about arithmetic," and so on

down; and when all of these are followed down in this inverse order and properly fixed, there is a fixed course of instruction; and when provision is made for giving the instruction in this course, there must be a fixed schedule; and by the time the fixed schedule is established, there is a fixed system just such as most colleges are following.

PROFESSOR WADSWORTH said that it seemed to him, from the discussion, that the trouble is that none of the gentlemen, or few of them at any rate, have ever used the elective system in engineering work, and consequently most of the criticisms do not apply to that system as it actually is. It should not be supposed that the speaker had no knowledge of a required system. In an experience of thirty-three years, during the chief portion of the time he had taught in a fixed system, and had used optional systems and required systems "ad infinitum" almost, so that with most of the purposes of the required systems he is familiar. From actual experience he would say that the amount of time, labor, drudgery and other things that the elective system does save, is something that he is unable to find words adequate to express, so that his hearers will understand it without trying it. This saving is an actual fact, speaking from experience, and an experience of long years with the different systems. In certain schools he would advise keeping the required system, and he certainly would be governed always by the practical requirements of each special case. He would not, in the case of another college, introduce any new system until he knew that a change would be proper and beneficial to the institution. Most of the objections which had been here made, apply to an

imaginary something, different from a true elective system. He would be glad to send to any one the catalogue of the Michigan Mining School, as it will show, as near as a catalogue can, how the elective system has been arranged there.

PROFESSOR GOSS said that he should regret to have it inferred from his previous remarks that he questioned the value of the work done in the institution with which Professor Wadsworth is connected. He could readily believe that Professor Wadsworth's plan might give good results, and desired simply to question whether the reforms which are stated to be the result of an adoption of the elective system could not have been brought about in some other way. If so, he thought that the success of the reforms should not be used as an argument to sustain the elective system.

PROFESSOR W. K. HATT found that his impression was not clear relative to one thing. The author said that when the student found out the incompetence of the instructor he would leave him and go to another class. The speaker wished to inquire if the student was permitted to control the character of his instruction, and, if so, on what features the student based his judgment.

PROFESSOR WADSWORTH replied that he hardly intended to convey that idea. It was stated that the elective system would show up the incompetence of the instructor, because the teacher in Mining Engineering or in any advanced subject would require that the students should have had proper instruction in calculus, analytic mechanics, mechanism, etc. If students came to that professor prepared properly, it would then be discovered that they were well taught; if im-

properly instructed, this would also be known as quickly; since, if any professor is to do his work rightly, the students must be thoroughly taught in the required preparatory subjects when they come to him. In other words, every professor naturally insists that the preparatory work for his classes shall be done as it should be, since stopping a student in one subject does not cost him a year's time, as it often does in the required systems. He must insist on this or it is fatal to his instruction. It is in part this necessary building up from the foundation in this way that makes the elective system's success. The students themselves are enthusiastic over their studies, and they do not wish to be under a teacher who does not do good work.

Further, it has resulted in a decided elevation of the moral tone. It has an excellent effect where there is an incompetent professor, or one who is exceedingly unpopular, or one who does not handle matters in the right manner. Instead of a class rebellion, or perhaps a petition presented to the faculty or board, accompanied with a statement that the students will leave the school, etc., the result is simply a resolve on the part of the students not to take the subjects that professor has the next year. It culminates not in a rebellion, but in the idea "I will not take that subject next year. I will go more into the civil engineering line, or the metallurgical line, or into some other subject that will enable me to avoid the obnoxious teacher." This attitude quickly shows itself and the trouble is readily diagnosed. The teacher is told by a live president what the trouble is, and he is obliged to do his work properly or leave the institution.

PROFESSOR BULL inquired if those professors who

offer "snaps," as they call them, become popular at once and attract the most students?

PROFESSOR WADSWORTH replied that they do not become popular in engineering colleges, but they do attract students to lectures in literary colleges, where there are usually numerous subjects that require no advanced preparation. The question of the literary education of a student is entirely different from the question of his professional education. The professional student in most cases knows that, unless his work is done well, he will not be a competent man in his profession after graduating. In the case of a literary college many of the students desire only athletics and to obtain a polish, consequently they elect anything that will give them their polish and degree. Further, in a literary college there is usually a much larger range of studies from which students can choose.

PROFESSOR M. T. MAGRUDER wished to ask Professor Wadsworth if his students are not very much older than the average student of the technical colleges?

PROFESSOR WADSWORTH said that the average age this year is 23 years; in former years it had sometimes been greater, sometimes less. Certain conditions in the Mining School may have raised it compared with most other colleges, notably the special students, since there have been some who were 56 years of age.

PROFESSOR KINGSBURY asked if he understood correctly that this system had been in use only one year at the Michigan Mining School?

PROFESSOR WADSWORTH replied that this was all.

PROFESSOR KINGSBURY said that he would be much pleased to hear at the next meeting how it works, and for several years following.

DISCUSSIONS.

On the Desirability of Instruction of Undergraduates in the Ethics of the Engineering Profession. By CHARLES CARROLL BROWN, Bloomington, Ills.

PROFESSOR M. E. WADSWORTH desired to ask for information, what is done in the different institutions in that direction? At the institution with which he is connected the subject of engineering contracts and the question of ethics and principles of engineering is taken up in connection with mining engineering and with mine management and mine accounts. Is not some provision of that kind made in almost all of the colleges?

The Study of Modern Languages in Engineering Courses. By THOMAS M. DROWN, President of the Lehigh University, South Bethlehem, Pa.

PROFESSOR M. E. WADSWORTH desired to ask a question: Could not the difficulty that Professor Fuertes has spoken of, be done away with by taking the stand that is taken in other professions, *i. e.*, that the so-called general training studies should be left out of the engineering curriculum? Is it not possible to occupy a high plane and say that the engineer is just as advanced professionally as anyone else? Can he not

start his professional training where the other professions do? Instead of asking the incorporation in the engineering college course of English Literature and numerous other subjects that belong to general culture and education, should they not be put into the preparatory school where they properly belong? The engineering profession is belittled by starting its education so low. Is it not possible to start it on the same plane that other professions select? In this way it would seem that the colleges could have genuine engineering courses and not be obliged to sacrifice their engineering studies to the continual demand for the interpolation in the course of literary subjects.

An Experiment in the Conduct of Field Practice. By FRANK O. MARVIN, Professor of Civil Engineering, University of Kansas, Lawrence, Kansas.

PROFESSOR M. E. WADSWORTH wished to speak about a point which does not affect the method of Professor Marvin as presented, nor the one Professor Fuertes had spoken of, but which simply describes an attempt to solve the question of field work in surveying in a special situation. Every institution must have its own methods. At the Michigan Mining School the question that presented itself to the institution at first, was some method of taking care of the practical as well as of the theoretical work. Also, in the time that was allowed the student, to give him an amount of experience that would enable him to apply his knowledge after graduation. That is, while he might know the theory, if he could not adjust his instru-

ments and practically meet the different problems likely to come before him, his previous study was worthless to him until he had learned later, by practice, how to apply it. The question was solved in this way: The ordinary summer vacation work is by most students taken as a vacation, a general good time; they do the work when they are compelled to, but they will not do it well unless absolutely obliged to. The failure of the summer school to impart real instruction becomes strongly marked if there happens to be in charge of it an instructor who is what students term "a good fellow," but who has no idea of real discipline or systematic instruction. The method that the Michigan college employed was this: all of the practical work was put in the regular year, or made part of the regular system. Thus the student's work in the summer time is as much a constituent part of the school course as it is in the winter term. To do this the regular school year was increased to 45 weeks. In the field surveying, the practical work covers various different subjects, like plane surveying, topographical work with stadia and plane table, geodetic work, railroad surveying, etc. The practical work in surveying, exclusive of mining surveying, occupies eleven weeks of the year, nine hours a day for five days a week, Saturday is taken usually in making up for the rainy days, for draughting, for making up back work, etc. The extra day is needed by many of the students, for while some are rapid workers, others are slow. The student in the field, in his surveying, is under the ordinary drill and discipline of the school, and he is made to work just as a

young surveyor is required to work when he commences his practice subsequent to graduation. The instruction in theoretical surveying has, heretofore, been given during the fall and winter terms. That has been found to be disadvantageous, owing to the fact that the student forgets the theory before he has time to apply it. Consequently during the school year 1896-7, the theoretical instruction will be given in connection with the field work of eleven weeks; that is, the student will hear the lectures and have his recitations in the morning at eight o'clock, going into the field immediately after, and applying the principles directly in practice.

PROFESSOR WADSWORTH explained that he believed all that Professor Allen said in regard to the value of practicing students in surveying during the later portions of their courses; but in the case of the Michigan Mining School the mining surveying, which is done underground in the mines in the spring, requires that the plane and railroad surveying preparatory to it shall come during the preceding summer. Further, since the mining surveying is preliminary to the mining engineering, the order in which the three subjects naturally fall is as follows: First Year: Plane and Railroad Surveying, Principles of Mining; Second Year: Mining and Mine Surveying, Theory and Practice; Third Year: Mining Engineering, Mine Managements and Accounts.

Is Not Too Much Time Given to Merely Manual Work in the Shops. By W. H. SCHUERMAN, Dean of Engineering Department, Vanderbilt University, Nashville, Tenn.

PROFESSOR M. E. WADSWORTH said that it seemed to him in listening to Professor Schuerman's paper that the ordinary manual training which was referred to in it is the work that is done in most schools by boys of the age of 15 or 16; while the shop practice of engineering colleges, properly speaking, is more apt to be done by young men of more mature age, and is a work of a different grade and character. For ordinary manual training, the speaker could see no objections to the author's recommendations.

He wished, however, to give the experience of the Michigan Mining School in handling shop practice for students of engineering, averaging 21 years of age and upwards. The speaker did this in the hope of bringing out the practical experience of others in like work.

At the Michigan college, the shop practice is considered to be of great value and use. The mining engineers have many occasions to use their knowledge of shopwork in the mines and about their plants. The graduates frequently express themselves strongly in favor of this work, as something that has proved very useful to them in their subsequent practice.

In order to take the shop practice and receive any credit in it at the Michigan college, it is required of every student that he shall have previously completed the requisite work in geometry, algebra, plane trigonometry, mechanical drawing, physics, general experimental chemistry, and the properties of materials.

The time given to the shopwork is eleven weeks during the summer term. It occupies nine hours a day. Five and one half weeks of the eleven are given to practice in wood-working, and five and one half weeks to metal-working. The class is divided into two sections which alternate ; that is, one half of the class works for five and one half weeks in the wood shop, while the other half works in the metal shop.

The preliminary practice in learning to handle the tools takes only a few days for the average student, usually two. After this introductory work, the time is spent entirely upon material that is to be used in the institution, *i. e.*, upon work which is of practical value.

The shops are conducted upon the principles in vogue in outside shops, and the student is made to understand clearly the value of time, material and quality of work done. Close record is kept of the time spent on each job, and any work which fails to pass inspection is promptly rejected. If any of the material has been destroyed by defective work, the student is required to pay the full value of the stock used up by his carelessness.

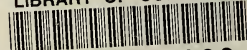
Experience shows that the students have a deep interest in their shop practice, because they feel that they are making something that can be used. In this way they receive the same mental training that comes in actual practice in planning and arranging work for their own or for commercial uses.

Lectures are given to the students upon the work and its principles, text-books are studied, and recitations are required, the same as is the case in the other departments of engineering.

After the shop practice has been completed it has been found by experience that it is of practical use as a preparation for more advanced subjects, like engineering design, metallurgical design, machine design, mechanical engineering, electrical engineering, laboratory practice both in mechanical and electrical engineering, ore dressing, etc.

The speaker would be pleased to learn of the practice and customs of other institutions, and how their instructors handle shop practice. Also whether or not the work has been found to be of vital interest and of real use to the students.

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